

Exploring the Challenges and Opportunities for Integrated Governance of Food, Energy, and Water Systems: Insights from Three Mid-Sized Cities

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Abstract

Governance of food, energy, and water (FEW) systems is complex and context-dependent. Existing research lacks much empirical research of FEW governance at the local level, especially in cities. This paper compares and contrasts FEW nexus governance in three mid-sized cities: Slupsk, Poland; Tulcea, Romania; and Wilmington, DE, USA. Using document review, semi-structured interviews, and citizen workshops, the comparative analysis examines the extent of collaborative and participatory governance in each case as well as the barriers and opportunities for expanding integrated nexus governance. Limited instances of collaborative and participatory governance emerged reflecting the local contexts and differing roles of non-governmental actors. The cases revealed a lack of awareness of the FEW nexus as well as a lack of opportunity for developing integrated governance or management strategies. Nascent conversations especially on sustainable development provide a starting point for deepening nexus governance in practice.

Keywords

Governance; public policy; cities; food-energy-water nexus; sustainable development; comparative analysis

Introduction

The food-energy-water (FEW) nexus concept was constructed to facilitate the study of complex intersections and interdependencies between food, water, and energy systems in supporting human life. The concept emerged during the World Economic Forum in 2011 to examine resource security (Simpson & Jewitt, 2019). The concept has gained traction globally for the study and practice of sustainable development.

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Reviews of FEW nexus research revealed the lack of empirical research on the FEW nexus especially on the local level, and at the urban scale (Newell et al., 2019; Tye et al., under review), where urbanization and climate change pressures are most likely to impose security threats for FEW systems and urban residents. These reviews note a lack of attention to the governance of FEW nexus systems, despite acknowledging the importance of integrating public policy and governance of the systems in pursuit of efficiency and resource savings (Hoff et al., 2019). Recommendations for integrating policy and governance of the FEW nexus require deep dives into the local context, and as such, most FEW nexus governance studies are single cases (Artioli et al., 2017).

This paper employed a comparative case study of FEW nexus governance in three mid-sized cities: Slupsk, Poland; Tulcea, Romania; and Wilmington, DE, USA. The social, economic, and political contexts of the cities are notably different, although the environmental context shows important similarities. The cases were independently investigated using a common research protocol and then comparative analysis identified commonalities and differences about FEW nexus governance. Information for the case studies was obtained from publicly-available documents and field research conducted in 2019-20, including citizen workshops and semi-structured interviews.

The comparative analysis revealed unique ways in which governance networks are structured in each city, in part due to the multi-level governance arrangements and differing roles of government in systems management. The analysis revealed a lack of FEW nexus awareness among participants and within policy or governance strategies at the urban scale in all three cases, despite noting some similar challenges across systems such as stormwater or food waste management. Institutional capacity was low at the urban scale to address FEW nexus challenges. Higher-scale organizations (such as state governments) did not provide much support to FEW governance in the three cases. The analysis revealed opportunities for improving nexus management through increased engagement of intermediary institutions, including universities and community-based organizations, and through emerging sustainable development strategies.

Conceptual Framework

The literature on the food-energy-water (FEW) nexus is large and interdisciplinary, although dominated by natural science and engineering and paying little attention to nexus issues within cities (Newell et al., 2019; Tye et al., under review). Some scholars see the FEW nexus as interchangeable with the “integrated urban agricultural food and nutrition system,” placing food at the center of the nexus and its sustainability (Schulterbrandt Gragg et al., 2018, p. 4). Other scholars see water as the focus (K. Portney et al., 2017; Simpson & Jewitt, 2019), emerging from the tradition of Integrated Water Resources Management (Pahl-Wostl, 2019).

We conceive of the urban FEW nexus as the interactions between the three provisional systems of food, energy, and water, which together influence the quality of life for city residents (see

Figure 1). Interruptions in the supply of the three systems can negatively influence personal livelihoods and collective security (Ramaswami et al., 2017). In our framework (Tye et al., under review), no system dominates and the FEW systems are nested within larger systems of governance, social and economic processes, and environmental stressors. Governance, social and economic processes, and environmental stressors comprise the context within which the FEW systems operate, and may function and interact at multiple geographic scales, from the neighborhood to the globe. This multi-scale context may be especially evident in smaller countries or at a particular historic moment.

Activities and the Nexus

The FEW systems incorporate multiple activities, which are connected through interactions of particular system actors, including government, business, and citizens (see **Figure 2**). The activities of all systems are constrained by activities of the governance system, including laws, regulations, and financing, as well as by organizational design and implementation strategies of the governance system.

Nexus linkages between FEW systems are extensive, context-dependent, and occur at multiple time and geographic scales (Schulterbrandt Gragg et al., 2018). For instance, water and energy are both inputs to agriculture, providing an opportunity to reduce water and energy demand through conservation or efficiency practices on the farm. Additionally, transport of food along the supply chain from farm to consumer requires extensive energy, especially for long-distance transport and storage (Augère-Granier, 2016). Local food systems can reduce these energy demands (Augère-Granier, 2016).



Figure 1. Conceptualizing the Urban FEW Nexus
Source: Tye et al., under review; adapted from Biggs et al. (2015)



Figure 2. Conceptualizing activities within the FEW Systems

Source: adapted from Tye et al., in review

Governance

Governance is the process of collectively addressing public problems and needs. Governance is associated with governmental functions, although recently, the academic focus shifted to activities extending beyond government into the private and non-profit sectors (Stoker, 1998). Governance activities may be formalized between institutions through policy or informal through self-organized networks of participants. Governance can be cross-scale or multi-level (vertical), cross-sector (horizontal), or both multi-level and cross-sector (Hoff et al., 2019).

Governance is influenced by the contemporary and historical social, economic, and political contexts (Rontos et al., 2015). Governance literature often examines the capacity to govern, which is influenced by the structure of the governance system, the characteristics of the system to be governed, and the interactions within the systems such as through policy or stakeholder participation (Kooiman, 2008).

Scholars and practitioners often assert normative aspirations for governance, including transparency, collaboration, and participation (Schmalz-Bruns, 2002). Collaborative governance means the involvement of multiple institutions in governance activities, while participatory governance means governance that solicits involvement of its stakeholders. Some public administration scholars more narrowly define “collaborative governance” as when a public institution arranges with a private or non-profit entity to perform public services (Donahue &

Zeckhauser, 2011). Collaborative and participatory governance is desired to increase the capacity, knowledge, or resources of governance institutions, and overall to increase the efficiency of public service delivery. Participatory governance is also desired as it supports democratic processes and may increase the transparency and legitimacy of governance (Few et al., 2007). To be participatory, governance activities need to involve two-way communication between stakeholders and governance actors.

FEW Governance

In the FEW nexus context, governance is the set of activities that manage each of the subsystems and the system as a whole, work to solve collective problems, and coordinate interactions. As Mohtar & Dahar (2016, p. 658) explain, “[g]overnance of the water-energy-food nexus is complex and relatively under-studied. The complexity results from the need to respond to the scale at which resources are governed, while simultaneously acknowledging the uneven distribution of power among the key players and decision-making focal points.” Often, the systems are managed separately with little interaction (Daher et al., 2019; Stein et al., 2018), leading to fragmented policies and unintended consequences (Weitz et al., 2017). Implementation of integrated FEW governance has been slow (Pahl-Wostl, 2019) and the field lacks examples of successful integration in practice (Hoff et al., 2019).

FEW governance literature is set within investigations of adaptive governance for ecosystem management (Schultz et al., 2015), which are set within broader investigations of environmental governance (Bennett & Satterfield, 2018). Prior research reveals the need for multi-stakeholder engagement processes for effective governance, but that this engagement complicates governance without appropriate institutional designs or rules-in-use (Märker et al., 2018). Effective adaptive governance also builds on the mobilization of diverse information, develops platforms for policy learning and coordination, and relies upon informal modes of governance beyond formal governmental authority (Schultz et al., 2015).

Nexus scholars provide multiple models for integrating FEW policy and management, including the “cross-cutting governance” framework in which each system has a strong governance structure called “disciplinary pillars” while also having a common platform for cross-sector coordination (Mohtar & Dahar, 2016). “Integrated governance” is the phrase used to characterize multi-level and cross-sector governance of the FEW nexus (Hoff et al., 2019). Other scholars using “integrated governance” note structural variants, such as one in which full integration of activities occurs within a new nexus governance body and another in which existing governance units cooperate in pursuit of a coherent policy (Märker et al., 2018).

Prior FEW nexus literature noted a lack of in-depth study of FEW nexus governance in its context (Artoli et al., 2017; Newell et al., 2019). We understand much more about the socio-technical aspects of the FEW systems (Ramaswami et al., 2017) than we do about how the nexus is managed and approached by people at the urban scale (Märker et al., 2018). The FEW nexus has been termed a buzzword that is abstract and technocratic, disconnected from real-life problems

(Bennett & Satterfield, 2018; Cairns & Krzywoszynska, 2016). The field has not often studied how the public understands the concept (K. E. Portney et al., 2018) and the nexus remains mostly invisible. Here we seek to build on the conceptual studies and to better understand the phenomenon of urban FEW governance in contemporary contexts through empirical research.

Methodology

This project employs a comparative case study of urban FEW governance within three mid-sized cities: Slupsk, Poland; Tulcea, Romania; and Wilmington, DE, USA. The case cities are set in differing social, economic, and political contexts although the environmental conditions are relatively similar. The three cities were selected opportunistically for a larger, multi-phase project² due to familiarity of the local project teams and alignment with the funder's objectives. As such, the cases can assist in building theory on urban FEW nexus governance but are not intended to be representative in a statistical sense (Yin, 2009).

The city is the primary unit of analysis. We broadly conceive of “the city” as a place containing a collective of actors and activities, situated at a defined point in time, but which evolves continuously over time (Harvey, 1997). In some instances, we expand the scope of analysis to the spatial scales covered by FEW system actors and activities and thus may reference “the city-region” including the city municipality, its surrounding county, state, or multi-state region.

The situation of each city within its context reflects a multiple-case design (Yin, 2009). We also have embedded units of analysis for the three FEW systems: food, energy, and water. Each system was analyzed within each case by the local study team, then interactions between systems were identified to construct a holistic vision of the phenomenon in each case. Our analytic framework examines, for each city, (1) the structure of governance across and between nexus systems (with formal and informal connections between actors); (2) whether that structure enables collaborative (multi-institution) and participatory (citizen-focused) governance as evidenced by interactions within the systems (Kooiman, 2008); and (3) the barriers to and opportunities for integrated nexus governance, including on data sharing and policy integration.

Information was collected by each city's study team from publicly available documents, semi-structured interviews, and public workshops with interested citizens (see **Table 1**).³ The interview guide was prepared for Wilmington (see Supplementary Material) and adapted for the other cases to be culturally appropriate. Knowledgeable interviewees were identified through public documents and by stakeholder recommendation. Interviews were conducted in person or electronically. Workshop attendees were solicited through local partners and public announcements. The interviews and workshops were conducted in the local languages.

Table 1. Primary Data Collection in Three Case Cities

² <https://creatinginterfaces.eifer.kit.edu/>

³ The data collection protocol for interviews and workshops in Wilmington, DE, USA was approved by the University of Delaware's Institutional Review Board in April 2019.

City	Activity	Dates	Involvement
Slupsk, Poland	Citizen workshop	May 2019	10 attendees
Slupsk, Poland	Interviews	March 2019 - May 2019	28 interviews
Tulcea, Romania	Citizen workshop	July 2019	43 attendees
Tulcea, Romania	Interviews	March 2019 - June 2019	30 interviews
Wilmington, DE, USA	Citizen workshop	April 2019	11 attendees
Wilmington, DE, USA	Interviews	April 2019 - July 2020	25 interviews

In most cases, interviews were audio-recorded and transcribed for qualitative data analysis; otherwise detailed researcher notes were used as primary source documents. Researcher notes and artifacts from the citizen workshops were transcribed and added to the interview notes for analysis. Notes were coded according to the conceptual framework presented above.

Data analysis proceeded in two stages. The local study teams first analyzed their collected information and produced case reports for each city in English. The second stage of analysis compared results across cases, seeking similarities and differences.

Case Background

The three cities are different in their social, economic, and political contexts, although their environmental contexts are relatively similar (see **Table 2**).⁴ All three cities are set in a temperate climate with warm to hot summers. Each city lies on a river near a larger water body and faces hazards from coastal and nuisance (storm) flooding, rising temperatures due to climate change, and the urban heat island effect.

Table 2. Selected characteristics of the study sites

	Slupsk, Poland	Tulcea, Romania	Wilmington, DE, USA
Population - city	91,007 (2018)*	73,707 (2011)	70,166 (2019) [#]
Population density	2,216 per km ²	596 per km ²	2,486 per km ²
Demographics	87.6% ethnic Polish (2011) §	83% ethnic Romanian	58% African

⁴ Additional details on the cases are visualized here:
<https://creatinginterfaces.eifer.kit.edu/spatial-visualization-of-the-five-nexus-with-storymaps/>

			American, 10% Hispanic (2018) [#]
Employment	3.5% unemployed* (2018) 7.3% of persons living in poverty	6.5% unemployed (2017)	4.2% unemployed (Jan 2020) [†] 25% of persons living in poverty (2018) [#]
Industries	Wholesale and retail, professional, construction, health care, transport, financial services, industrial	Industrial (shipping, chemical and metallurgical), food, transportation, agriculture	Healthcare and social services, retail trade, finance, and insurance [#]
Land surface	~ 30% impervious surface	~ 18% impervious surface	~ 80% impervious surface
Climate	Humid continental (Koppen: Dfb) [‡]	Humid continental (Koppen: Dfa) [‡]	Humid continental (Koppen: Dfa) [‡]
Location	On Slupia River, near the Baltic Sea	On Danube River, near the Black Sea	On Delaware River, near the Atlantic Ocean

Sources: * Polish Central Statistical Office; § Polish Statistical Office in Gdansk; [#] U.S. Census Bureau; [†] U.S. Bureau of Labor Statistics; [‡] National Institute of Statistics Romania; Plantmaps.com.

Slupsk is a city in northern Poland, along the Slupia River and near the Baltic Sea. Approximately 180,000 residents live in the city-region, with 90,000 residents in Slupsk city and another 90,000 residents in Slupsk county (Central Statistical Office, 2020). The city's population and economy declined since the country's transition to democracy in 1989; it is now rebuilding.

Tulcea is a city in southeastern Romania, along the Danube River and near the Black Sea. The city-region has a combined population of nearly 200,000 residents, with approximately 74,000 residents in the city (as of 2011). The city is set within the extensive wetlands of the Danube Delta. Tulcea's population also declined in the post-communist era.

Wilmington is a city in the mid-Atlantic region of the eastern United States. The city's population has remained stable since the late 1970s at approximately 70,000 residents and is surrounded by a growing suburban population in New Castle County of approximately 500,000 residents (as of 2019). Wilmington's population is majority Black and majority low-to-middle income, with the high poverty levels characteristic of larger American cities.

Results

This section details findings from each case concerning: 1) the governance structure, 2) the extent to which governance is collaborative (multi-institution) and participatory (citizen-oriented), and 3) the barriers or opportunities to collaborative and participatory governance of the FEW nexus. A comparative analysis follows.

Macro-structure

Poland and Romania joined the European Union (EU) in 2004 and 2007. As such, Slupsk and Tulcea operate within a multi-level governance structure, with actors ranging from the supra-national scale (the EU) to national, sub-national (provincial), county, and local scales. In part due to their shared socialist history, governance is often top-down and highly bureaucratic.

Governance has a parallel structure in Poland, with the “public” system comprising the national government and its lower-level units, and the “local” system comprising the municipal government and its activities. Localities exhibit limited self-governance over FEW systems.

In Romania, the attraction of EU funds for FEW-related initiatives was initiated at the regional level. Otherwise, dominant FEW institutions operate at the county level.

The United States has multi-level governance but without an equivalent supra-national level as with the EU. Governance is more decentralized in the United States. Local self-governance varies by state; Wilmington city has self-governance over the municipal water system but has little influence on energy and food.

Case Study 1: Slupsk

Food

Slupsk’s food system is demarcated between industrial food production and local food systems. The city and county have more than 23,000 farms, with most agricultural land under the control of a few large enterprises, but also the majority of farms being small in size (less than 5 hectares) and family-owned (Central Statistical Office, 2020). Food is central to the local economy; nearly one in five working-age residents are employed in agriculture, forestry, fishing, or the food industry in the city-region.

Public and local government actors dominate the food governance network in Slupsk. Nevertheless, actors are “siloeed” depending on whether their focus is agricultural production, consumer health and safety, environmental protection, or some related topic (i.e., allotment gardening). Activities and tasks are not coordinated across organizations.

Two central actors in the Slupsk food system operating at the local (county) level are the Agency for Restructuring and Modernization of Agriculture (ARMA) and the Agricultural Advisory Center (AAC). The ARMA distributes national and EU funds for agricultural development and monitors its use, producing some relevant data for use by other institutions. The AAC provides advice and education for farmers and conducts agricultural development.

Governance responsibilities are sometimes shared between entities in the public system (i.e., the national, regional, and county levels). For instance, the AAC interacts with farmers most directly from its county office but its development projects (such as for model farming and beekeeping) are conducted by its regional office.

Only three non-governmental organizations were identified within the Slupsk food system: the local Food Bank (which is connected to a national network), the Regional Farmers Chamber (which has ties to the national governing party), and the Slupia River Basin Partnership (which operates under EU policy and connects local producers).

Little opportunity exists for citizen involvement in food governance in Slupsk. The most active food system actors (e.g., AAC) communicate to rather than partner with its stakeholders.

A few barriers to collaboration within the Slupsk food system were identified. Until 2017, farmers were prohibited from selling their products directly to consumers. Today, direct sales are limited to family farms and those with annual sales less than 10,000 Euros. Environmental data reporting is not required of the small and medium-sized producers and processors, leaving gaps in knowledge on important FEW system linkages and impacts such as agricultural water pollution. Additionally, relevant data are often not made publicly available or shared between organizations, with agencies like ARMA being slow to share information and incomplete information at that. In some instances, a public organization purchased needed data from another public organization.

Water

The Slupsk water system is also dominated by public and local government actors. The central organization is the public utility company Water Supply Slupsk, which provides drinking water and sanitation services to residents in Slupsk city, county, and in nearby Kobylnica county.

Water Supply Slupsk implements the Water Safety Plan (WSP), an initiative of the World Health Organization involving multiple city departments (emergency management, environmental protection, housing, sanitation safety). Water Supply Slupsk has a local advisory board and is controlled by various city, county, and regional organizations, including the Regional Water Management Board in Gdansk (which reports to the national Polish Waters agency). Water quality is regulated by the public environmental protection bureaucracy at local, regional, and national levels.

The Chief Executive Officer (CEO) of Water Supply Slupsk participates in public advisory committees such as the Sustainable Development and Green Modernization Council, the Business Council, and the Chamber of Commerce and Industry. The CEO is an important leader in the local water system and more broadly within sustainable development for the city, exhibiting charismatic leadership (Conger & Kanungo, 1998).

Water Supply Slupsk's wastewater treatment plant conducts environmental outreach and coordinates with regional environmental education initiatives. The company cooperated with the city's environmental protection department on a public campaign to encourage drinking tap water to reduce plastic bottle consumption and associated waste management.

The water system engages with stakeholders in a one-directional fashion with no opportunity for substantive citizen input into governance. Water system managers subscribe to the "cognitive deficit" model in which supply of information would be sufficient to change consumer behavior, despite recognition that public understanding of risk information is low (Wynne, 1991).

Data management appears problematic in the Slupsk water system, with large quantities of data collected in differing formats and with little capacity for integrated risk analysis. Nevertheless, information sharing was not seen as a problem between the water system actors.

Energy

The energy system in Slupsk is the most commercialized and centralized of the three systems, especially on energy supply. Energy is provided by powerful private companies under contract with the government to customers as heat, electricity, or gas. Renewable energy is expanding in the Slupsk city-region, with new wind installations and some private solar energy systems on buildings. Both Water Supply Slupsk and Communal Management Company (which operates the waste management facility) plan to expand their renewable energy production.

The local energy system is managed by a set of institutions from the national level (i.e., Ministry of Energy and the Energy Control Office), the regional level (e.g., the Department of Environment and Agriculture), and the city level (e.g., the Department of Municipal Management and Environmental Protection). The Regional Council for Energy Security advises on translating the national energy goals to local conditions and sustainable energy development activities. The City Office remains the point of contact for system actors and coordinating on occasion. For instance, the city's staff in Sustainable Development advises on sustainable energy development and coordinates with the city's Sustainable Development and Green Modernization Council.

The research revealed some inter-institutional cooperation through the BioEnergy Cluster, which brings together the Slupsk city office, the Pomeranian Agency of Regional Development (regional level), Water Supply Slupsk, the local heat energy provider Engie SC Slupsk, and other energy businesses and providers. The Cluster plans a heat distribution pipeline and electric car charging infrastructure.

Related, the Slupsk Technology Incubator has several renewable energy projects, collaborates with business and environmental organizations about energy efficiency, and works with local schools and universities (such as the Gdansk University of Technology) on ecological and technical education. Additionally, the BioEnergy Cluster, the Technology Incubator, and Water Supply Slupsk cooperate on equipping buildings with renewable energy and energy efficiency technologies, such as at a local homeless shelter.

Energy data are not published in a coordinated or consistent fashion, but system actors did not see the need for such efforts. As with water data, communication of energy information is directed at the public with minimal efforts aimed at engaging citizens in governance. Citizen communications are often educational, such as on how to save energy in individual households.

Nexus

In Slupsk, water, energy, and food systems operate separately and the institutions that regulate them rarely interact. Most institutions are reluctant to cooperate in management or share data with other institutions if not required by law. Institutions in Slupsk were not very participatory, with few options for citizens to be involved. Instead, government institutions focused on one-way communication and education to stakeholders.

Interview respondents in Slupsk did not often evidence awareness of the FEW nexus. Only general connections could be identified, such as the impact of agricultural activities upstream on water quality in Slupsk city. The local university did not appear to play a bridging role between nexus institutions.

One institution connected to the three FEW systems is Water Supply Slupsk, which provides drinking water and sanitation, generates energy from biogas through sewage fermentation, composts waste, and provides fertilizer to consumers. Water Supply Slupsk has photovoltaic installations and it also educates farmers on best management practices to reduce the need for water treatment.

Another institution connected weakly to multiple systems is the Green Dot initiative at the local library, which educates residents about growing food, energy efficiency, waste sorting, and other topics. The initiative was established by the mayor and the Sustainable Development and Green Modernization Council of Slupsk City, with participation from other city offices and Water Supply Slupsk. While limited, Green Dot has the potential to build dialogue between institutions and citizens on the nexus.

Case Study 2: Tulcea

Food

The Tulcea food system also exhibits characteristics of an industrial food system and a local food system. Agricultural activities are split between individual farmers, the Agricultural Producers Association, and corporate farmers, across 538 hectares (2.7% city's land area). Agricultural production is governed by the Tulcea City Council, the National Sanitary Veterinary & Food Safety Authority and the Public Health Authority through their county-level offices, and the national General Directorate of Agriculture. County offices implement the government's strategy and policy in the field of consumer protection, acting to prevent and combat practices that harm the lives, health, security, and economic interests of consumers. Both the Sanitary Veterinary and Animal Safety and the Consumer Protection offices have online data-sharing information platforms where citizens can find information about products and services present in the market.

One of the institutions in the Tulcea food system connecting producers with consumers is the Agro-Food Market, which is supervised by the private company SC Agropiete S.A. on behalf of the city government. Some evidence suggests that consumers are shifting their purchasing habits from the agro-food markets to supermarkets and that the agro-markets cannot compete with their lower prices and more extensive selection. A lack of greenhouses may be constraining food production, especially for vegetables in the winter, leading to imports from countries with warmer climates.

Energy

The energy system in Romania is highly centralized and regulated centrally, with regional subsidiaries of the national energy companies connecting with consumers. The Tulcea city-region has some renewable energy development in solar and wind power, which report their generation to the Agency for Environmental Protection in Tulcea County. The city-region has substantial wind energy potential as compared to the rest of the nation. Wind installations in Tulcea County were producing approximately 5,800 megawatts of electricity as of 2013.

Water

The main competitive advantage of Tulcea city is its geographical position: on the Tulcea Branch of the Danube River. The primary actor in the Tulcea water system is SC Aquaserv S.A., for which the Tulcea Local Council is the main shareholder (alongside Tulcea County Council, Sulina Local Council, Isaccea Local Council, Macin Local Council). This company is delegated by contract to provide drinking water and wastewater management. The company is jointly investing with the city in upgrading its drinking water distribution network. Drinking water quality is monitored and regulated by the Public Health Directorate in Tulcea.

Before the contract award to SC Aquaserv in 2007, the cities in the region collaborated through the Inter-Community Association (ADI) to develop a regional water and sewage management strategy. In 2008, the company received a European Commission project grant to upgrade its drinking water and wastewater system and facilities in Tulcea city and major towns in the county.

Nexus

A few nexus interconnections are noted in Tulcea. SC Public Services S.A. is a private company that contracts with the city to provide sanitation services, greening, and other infrastructure maintenance. As in the other cases, sanitation links the three systems as it links into wastewater treatment, collects solid waste that includes food waste, and requires energy for both transport and facility operations. Related, the food and water systems are connected via regulation of the Public Health Authority and overseen by the City Council, which is a shareholder in both the SC Aquaserv (water) and SC Public Services (waste) operating companies.

Additionally, the Danube Delta Biosphere Reserve Authority (ARBDD) is a public institution chartered by the national Ministry of Environment, Waters, and Bridges to oversee the largest protected area in Romania, the Danube Delta Biosphere. ARBDD regulations apply to all agriculture, construction, and other industrial activity (including energy) in the protected area.

A nexus connection between food and energy at the national level is through the National Authority for Consumer Protection (ANPC). In 2017, approximately 30% of the ANPC's control actions related to food products and 8% related to food-service. The ANPC also cooperates with the National Regulatory Authority for Energy in regulating electricity, heating, and natural gas markets throughout the country, and regarding efficiency, competition, transparency, and consumer protection.

Tulcea's water, energy, and food systems operate separately, as in Slupsk, and the institutions that regulate them interact rarely. Most institutions are reluctant to cooperate with other institutions if not required by law. Institutions in Tulcea offer few options for citizens to be involved with policy or management. Instead, government institutions focus on one-way communication with stakeholders and educational activities using mostly European funding.

Interview respondents in Tulcea did not often evidence awareness of the FEW nexus but did acknowledge its significance for resource management. For instance, ongoing conversations identified FEW nexus problems in the area of Zaghen Lake (such as water for irrigation) that were discussed with citizens and stakeholders at the first project workshop in July 2019. Additionally, specialist knowledge from the nexus-related institutions is growing and integrated governance for sustainability is starting to be introduced.

Case Study 3: Wilmington

Food

Commercial agriculture is an important part of the Delaware state economy and accounts for more than 40 percent of the total land use of the state (Mammarella, 2014). In Wilmington city, however, the food system is dominated by local food actors operating mostly through their personal contacts. No entity coordinates food governance in Wilmington.

Public actors are involved through land-use zoning and food safety regulation. The national Department of Agriculture (USDA) provides funding and emergency food for nutrition programs implemented locally.

The city government partners with the non-profit Wilmington Neighborhood Conservancy Land Bank, which cleans up abandoned properties and facilitates sales to new owners. The Land Bank promotes community gardening and cooperates with the non-profit Delaware Center for Horticulture, which operates a small urban farm and assists in establishing community gardens.

Portions of Wilmington have been identified as “food deserts,” where access to commercial grocery stores is poor. The food selection at accessible stores can be unhealthy and expensive. One response is the Wilmington Corner Store Initiative, which works to bring healthy and affordable foods and nutrition education to neighborhood stores. Recent efforts to expand the initiative statewide have been led by the Delaware Farm and Food Policy Council (FFPC), which advises the state Governor and is coordinated by the state Department of Agriculture. Interested parties also participate in the Urban Farm and Food Coalition, providing education and technical support to growing activities on private properties, schools, and community gardens.

Two food governance challenges in Wilmington are scale and resources. Most local food efforts are localized, such as for one community or school garden in one neighborhood, or with limited-season farm stands. Organizations are under-resourced and hesitant to cooperate, as they compete for funding. Resources are scarce for expanding the industrial food system. Initial conversations are underway to create a food distribution hub to connect city consumers with commercial farms. The food hub could serve as a coordinating mechanism for food governance in Wilmington, if adequately resourced.

Related, food-related data are decentralized and difficult to compile for Wilmington city. Public requirements for data reporting by food establishments are minimal and consumption data are compiled whenever funding is available.

Energy

The energy system in Wilmington is privately operated and the governance structure is opaque. Electricity and natural gas are provided to consumers by Delmarva Power, which is a private investor-owned utility under the Exelon Corporation.

Energy providers and facilities are regulated by the state's Public Service Commission and the state's environmental protection agency (DNREC). DNREC oversees the state's weatherization program and other grant funding.

Electricity is purchased for municipal buildings by Wilmington city's Department of Public Works (DPW), which also manages a small renewable energy project at its wastewater treatment plant (WWTP). The city's Housing Authority installed a small solar farm in South Wilmington. The city's Mayor and DPW also partnered with Delmarva to replace street lighting and install smart sensors throughout the city, after an initial demonstration project nearly a decade ago (The City of Wilmington Delaware, 2019).

The statewide non-profit Energize Delaware aims to expand energy efficiency and renewable energy (EERE) throughout Delaware. It is partly state-financed. Energize Delaware provides education, technical assistance, and grants to individuals, businesses, schools, churches, and other non-profit organizations, including farmers and the Food Bank of Delaware, which distributes emergency food.

The biggest challenge in energy governance in Wilmington, as in Slupsk, is its private nature. City actors provide limited incentives to private companies, such as the lighting partnership, but have little influence otherwise. Cities like nearby Newark, Delaware have municipal energy cooperatives, which directly control purchasing behavior and involve citizens in governance.

DNREC and Energize Delaware prepare extensive reports with data on the state's energy policy implementation. As in Slupsk, localized consumption data are not required to be provided publicly by private energy companies.

Water

Public actors dominate Wilmington's water system. The primary actor is the DPW, which provides drinking water, sewer, and stormwater services. The water system is overseen by a citizens' advisory board. The WWTP is operated by a private company under contract with DPW, and the city is replacing infrastructure throughout the city in partnership with private contractors.

DPW implements state and federal water quality laws, and coordinates with regulatory agencies such as DNREC, state public health and transportation departments, and the federal Environmental Protection Agency (USEPA). DPW also coordinates with other water-related organizations such as the Water Resources Agency at the University of Delaware, the New Castle

County Conservation District, and the multi-state Delaware River Basin Commission. Many of these actors participate in the state's Water Supply Coordinating Council, which includes private citizens and advises the state on water policy.

The city has invested in street trees and green infrastructure for stormwater management. One example is the South Wilmington Wetland Park, which is near the Christina River, has faced routine surface flooding, is at further risk from sea-level rise, and has a legacy of industrial contamination. The wetland park evolved from a community planning effort in partnership with its civic association and neighborhood planning council, city staff, DNREC, the Nature Conservancy (a national non-profit organization), the National Oceanic and Atmospheric Association (NOAA), and a local business contracted to remediate contaminated soils.

A similar community planning effort to revitalize neighborhoods along the Brandywine Creek in Northeast Wilmington is underway. The effort involved local businesses and residents, the city's planning department, DNREC, NOAA, the non-profit Partnership for the Delaware Estuary, the University of Delaware, among others.

Overall, this network of water actors exhibits the strongest evidence of collaborative and participatory governance of the three systems in Wilmington. Substantial data have been collected and shared on the water system. Interviewees noted the need to standardize and centralize databases, but that data sharing has proceeded smoothly among organizations.

Nexus

Elements of Wilmington's water system interact with elements of the energy and food systems in a complex governance network. Citizens were incorporated through the South Wilmington Wetland Park, the Northeast Revitalization Plan, and through advisory councils.

Most interviewees were not familiar with the nexus concept but could see linkages when prompted. For instance, water and energy are required inputs for urban agriculture and water treatment for agricultural contamination requires energy. Transport energy for food access was a limiting factor for city residents.

FEW nexus governance is complex in Wilmington, given its proximity to other states (Maryland, New Jersey, and Pennsylvania). Wilmington's drinking water supply originates in Pennsylvania and its quality is influenced by agricultural activities there, requiring energy-intensive treatment in the city. The city adopted a Source Water Protection Plan allowing the city to pay farmers to employ management practices reducing sediment and contaminants. The payments are expensive, however, and implementation is limited.

Wilmington city has a nexus opportunity in waste management. Composting could reduce energy and water demand for food waste management. The city previously licensed a commercial compost facility, which was shut following poor environmental performance and public opposition

to traffic and odor. The city may hesitate to support another centralized compost facility. Nevertheless, restaurants and food retailers assert the need for specialized management of food waste. The city uses recovered biogas from its landfill to power its WWTP, as does Water Supply Slupsk, exhibiting capacity for integrated management of water and energy around waste.

Comparative Analysis

The comparative analysis revealed unique ways in which governance networks are structured, resulting from disparate institutional systems and history.

The governance structures in Slupsk and Tulcea are relatively similar because of their shared socialist past, the transition to democracy in 1989, and membership in the EU. Post-transition governance is characterized by a low level of trust in government institutions, low participation in the public sphere more broadly, and low density of civic associations and non-governmental organizations (Giordano & Kostova, 2002; Grabher & Stark, 1997). Post-transition governance is also top-down with a low level of cooperation between institutions, revealing the “embeddedness” of institutions within their legal and regulatory contexts (Stein et al., 2018). Yet, nascent collaborative nexus governance was apparent in Slupsk and Tulcea, such as through Water Supply Slupsk and the Danube Delta Biosphere Reserve Authority in Tulcea.

Wilmington has disconnected governance of its FEW systems, with food-water and energy-water connections but little integration across all three systems. This situation seems typical of urban cases (Tye et al., under review). Notably, Wilmington involves more citizens and non-profit organizations in governance than in the other two cases. In Wilmington, many public institutions have advisory councils composed of private citizens and non-governmental stakeholders, and each neighborhood in the city has a planning council connected to the local civic associations and the city government. Representatives on advisory councils cross between sectors and levels, strengthening the network of actors within the city. These interactions were not always obvious from formal governance structures but were noted in interviews or by joint membership in initiatives like the UFFC. Nevertheless, interview and workshop participants noted that citizens, especially from minority neighborhoods, were difficult to engage in governance activities, and that “usual suspects” with more power dominated citizen engagement (Few et al., 2007).

The governance structures in all three cases revealed fewer institutions and interactions with energy than with food or water at the local level. Our literature review found this situation is typical of urban cases (Tye et al., under review, Figure 3). We suspect the lack of actors reveals the centralization of energy infrastructure and its governance, although further research is needed on this point. The development of alternative energy sources may contribute to greater energy decentralization and greater involvement of citizens and non-governmental organizations. Such efforts are expanding with biogas in Poland and for private renewable energy systems in Germany, promoted through national and EU-level incentives.

Public health and environmental protection regulatory bodies were involved in FEW governance in our cases but did not exhibit FEW nexus integration of policy or management. The analysis revealed a lack of FEW nexus awareness among participants. Thus, the three cases did not demonstrate the characteristics observed in successful adaptive governance, starting with a broad information base on the nexus and its dynamics (Schultz et al., 2015).

Institutional capacity was low at the urban scale to address FEW nexus challenges in our three cases. Nevertheless, the national and local management system and regulations are of strong importance and can be an important factor in strengthening FEW co-management (especially for Słupsk and Tulcea). For example, Poland has national legislation on urban revitalization, which strengthened intersectoral management and cooperation through local revitalization plans. Implementation was uneven but the policy introduced better management that could incorporate FEW nexus thinking.

Within city networks, opportunities for improving nexus management may come through increased engagement of intermediary (bridging) institutions, including universities and community-based organizations. In post-transition cities like Slupsk or Tulcea, changes in regulatory frames inhibiting cooperation between institutions seem necessary before substantive efforts at integration emerge.

Another opportunity would be to acknowledge the FEW nexus importance for sustainable development and its introduction in local development strategies (as was recommended by Hoff et al., 2019). The Sustainable Development and Green Modernization Council in Slupsk city provides a possible model for convening cross-sector discussions that precede policy development, although the Council is only advisory in Slupsk. An important question is how to increase the empowerment of such advisory bodies.

Economic insecurities plagued Wilmington residents before the COVID-19 pandemic and the pandemic has only amplified these challenges. In response, multiple actors turned their attention to food insecurity. Such insecurity concerns were the original focus of the FEW nexus and raise the potential of efficiency gains through integrated nexus governance.

Conclusions

This paper explored the governance of food, energy, and water systems in three mid-sized cities: Slupsk, Poland; Tulcea, Romania; and Wilmington, DE, USA. The goal was to determine to what extent the governance structure and practices were collaborative (involving multiple institutions) and participatory (involving citizens and non-governmental organizations), as is expected for integrated governance (Hoff et al., 2019).

This research revealed common points relating to the peculiarity of FEW nexus management in cities:

- **Inadequate integration of institutions managing individual FEW subsystems.** The systems themselves (Food, Water, Energy) are complex, multi-level, multi-sector, and involve regulatory systems spanning different geographies. Most institutions are locked in management silos. This result is especially true for public sector institutions, which are aligned towards legally-defined tasks and relationships.
- **Lack of functional relations between actors within the FEW nexus.** The tools presently available for the exchange of knowledge and information between individual subsystems of the nexus are inadequate. Institutions have few to no functional activities to communicate, integrate databases, and align knowledge and decision-making systems concerning FEW issues.
- **Invisibility of the nexus.** Despite some differences between cities, all three cases revealed a lack of awareness of the FEW nexus or its possible role in urban governance. We found no visible or effective infrastructure for this purpose. Even when respondents were aware of FEW nexus connections in their city, this awareness did not translate into processes for managing those connections.

Technical integration of subsystems is not the primary issue in our three cases, contrary to initial FEW nexus studies. The two principal problems identified here are low awareness of nexus linkages and the absence of networks to manage them. The nexus only becomes visible in specific instances of urban management problems, such as waste management. However, the lack of a governance framework for managing this nexus issue precludes effective dialogue and decision-making between systems and actors at different levels, scales, and sectors.

The project results indicate that visibility of the FEW nexus is the key challenge to overcome, by visualizing connections, integrating data systems, building relations between institutions, involving citizens, or supporting integration policies of sustainable city development. Future research must pay greater attention to the case variations with their unique historical, institutional, and social contexts. Otherwise, development of a nexus governance framework that could operate in Wilmington, where civic networks are denser and relations with the private sector are complex, may not be suitable for cities like Słupsk or Tulcea, where the public sector dominates and the basic problem is its multi-level integration and inclusion of citizens.

Finally, we would like to draw attention to the problem of energy assimilation in FEW nexus governance. It is easier to see linkages between water and food at the city level, while energy remains somewhat disconnected. More conceptual emphasis must be placed on understanding associations between energy and the other FEW subsystems at a scale substantially smaller than most energy systems operate. Distributed, renewable energy systems may provide linkages to the other subsystems at the urban scale, but account at present for only a small portion of total energy consumed.

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